Inside NIDCD Newsletter

National Institute on Deafness and Other Communication Disorders
National Institutes of Health

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Feature Story

The Sweet Taste of Expectation

by Robin Latham

You were late getting to the awards luncheon. When you arrived, the kitchen staff had already removed the entrees and so all you could toss onto your plate was some hastily assembled salad—but at least there were a few of those small grape tomatoes that you love. Grabbing one of the last seats at a table, the lights went down and you speared a tasty oval with your fork, popped it in your mouth and looked forward to the juicy burst of tomato goodness. Except that's not what you got. What you got instead was something dense and rubbery and with a flavor that you couldn't figure out at first until you realized that you were chewing on an olive.

What happens during that moment when expectation and sensation meet in the mouth is what fascinates Alfredo Fontanini, M.D., Ph.D., an NIDCD grantee and 2010 winner of the Presidential Early Career Award for Scientists and Engineers (PECASE), the highest honor given by the United States government to science and engineering professionals in the early stages of their independent research careers. He and his laboratory team at Stony Brook University in New York study the gustatory cortex, the area of the brain that processes and interprets taste. In his way of looking at things, taste isn't just a straight-up report from the taste buds on our tongue. His studies suggest taste is created in the brain and that psychological states—anticipation, expectation, and attention—have such a profound influence on the process that no two bites, or sips, taste exactly the same.

Alfredo Fontanini, M.D., Ph.D.
Credit: **Photo courtesy of Dr. Fontanini**

Recently, Dr. Fontanini and his team have been studying the impact of expectation on taste processing by measuring the responses of neurons in the gustatory cortex of rodents to specific cues and taste stimuli. "We train our rodents on a go/no-go task that uses two auditory tones—one signals the availability of a pulse of sugar water and the other the availability of a pulse of bitter water—and there's a lever that the rat can push to get a taste," he says. Over time, the animals learn to press the lever following the "sweet" tone and not to press when they hear the "bitter" tone, and their behavior tells the researchers that they have learned to expect specific tastes on the basis of the auditory cues.

Looking at how the neurons respond in the gustatory cortex, Dr. Fontanini and his teammates observed that their response becomes cue specific. Distinct subsets of neurons display patterns of unique activity that are specific to either the anticipation of something sweet or something bitter.

To further test the role of expectation, they fooled their subjects. "We play the sweet tone," says Dr. Fontanini, "but sneak in a taste of bitter to see how neurons respond to misleadingly cued tastes. What we see is something that looks more like the response to sweet, particularly at the beginning—as if just the expectation itself biases the response—and then it eventually converges into a response that looks like bitter." The neurons also took a longer amount of time to eventually exhibit bitter-specific activity.

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These findings suggest that what goes on in the gustatory cortex isn't just neurons encoding what they receive from taste receptors on the tongue. Apparently, just the expectation of what you're about to taste is enough to create taste-specific activity in the gustatory cortex that, along with sensory information from the tongue, ultimately shapes the neural coding for taste.

According to Dr. Fontanini, this approach to taste integrates the study of two systems—the sensory system and the reward system—that have traditionally been studied separately. The common wisdom has been that sensory systems receive information from the outer world and expectation is processed in another area (or areas) of the brain. But what Dr. Fontanini's research appears to be telling us is that reward areas are communicating directly with sensory areas to determine expectations and emotions.

If so, then the study of taste offers an excellent model to understand how any kind of sensory stimuli is shaped by psychological state. "In taste, the hedonic value—whether it tastes good or it tastes bad—is so central to perception," says Fontanini, "that it offers the unique possibility to study how sensory and emotional processes are intermingled."

The implications of these studies could go beyond a better understanding of taste coding in the brain and also lay the groundwork for other researchers to begin to explore potential neural networks involved in eating disorders, addictions, and depression—all of which are characterized by alterations in reward systems.

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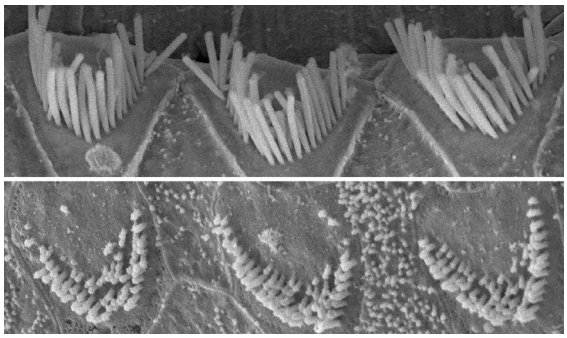
Recent Research and News

NIDCD Researchers Discover Unique Protein that Appears to Control Stereocilia Length

Stereocilia, bundles of super-sensitive fibers perched atop the sensory cells that line the inner ear, are the structures responsible for converting vibrations entering the ear into electrical signals that travel to the brain and say "sound." The height and staircase formation of stereocilia are precise to within a nanometer (a measure of length so tiny it would take a billion of them to stretch almost the length of a yardstick) but scientists know very little about what regulates stereocilia length—how do they know when to stop growing? That question is beginning to be answered by the discovery of a protein called Eps8. Along with two other proteins, whirlin3 and myosin XVa, EPs8 appears to control stereocilia length at an extraordinary level of precision. The discovery was made in NIDCD scientist Bechara Kachar, M.D.'s Laboratory of Cell Structure and Dynamics, aided by a team of scientists in Italy. According to Dr. Kachar, the three proteins interact to make and maintain actin, the primary component of stereocilia. myosin XVa is the motor element that transports EPs8 and whirlin to the tips of stereocilia. Once they are there, whirlin has special scaffolding properties that help actin stick to the tips, while Eps8 tells the actin when to stop accumulating. Next, the team will be looking at the molecular details involved in exactly how Eps8 regulates stereocilia length.



Mouse stereocilia without Eps8 (bottom) are much shorter than normal (top).
Credit: **Uri Manor and Leonardo Andrade**

Read more on the NIDCD website at **http://www.nidcd.nih.gov/news/releases/11/02_07_11.htm**

The findings have been published in Current Biology at **http://www.ncbi.nlm.nih.gov/pubmed/21236676**

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Doing the 'Stereocilia Wave'

Stereocilia are bundles of super-sensitive fibers perched atop the sensory cells that line the inner ear. They're responsible for converting vibrations entering the ear into electrical signals that travel to the brain and say "sound." How do they move to create their electrical signal? Most researchers picture them bowing in unison, as if they were in a three-row line dance doing the Cupid shuffle or the electric slide. Sonya Smith, Ph.D., a professor of mechanical engineering at Howard University, and Richard Chadwick, Ph.D., chief of the NIDCD Section on Auditory Mechanics, see things differently. To them, it's more like they're doing the wave. The difference, they say, is that the inner ear is filled with fluid, so forces that are acting on the individual stereocilia are different than if they were surrounded by air. Using a model that predicts the movement of large objects, like submarines and parachutes, and applying it to stereocilia on the sensory cells (called inner hair cells) in the inner ear, the researchers found that rather than bowing in unison, the first and third rows of stereocilia rotate to one side, while the middle row doesn't rotate at all, but stretches up and down, as if it were in a stadium doing the wave. They also found that the layer anchoring the stereocilia to the hair cell moves in an orbital fashion and the membrane lying overhead (called the tectorial membrane) remains stationary at a key height above the stereocilia tips. If the membrane were any higher, special gates that let ions inside would not open properly. Finally, they discovered that the sudden movement of the gates opening creates a vortex that helps usher the ions inside, which helps start the electrical signal.

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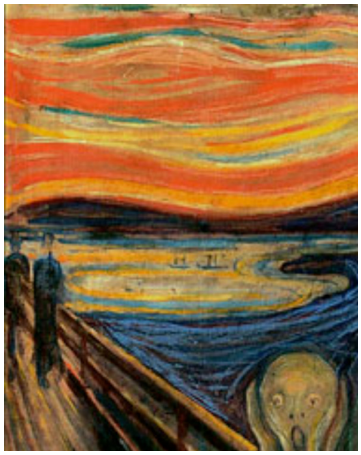
Read more on the NIDCD website at **http://www.nidcd.nih.gov/news/releases/11/042211.htm**

The findings have been published in PloS One at **http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0018161**

Novel Theory for Tinnitus Results from ARRA Funding



Tinnitus is a ringing in the ears that won't go away. (The Scream, Edvard Münch, 1893)

Why some people with hearing loss develop tinnitus—a buzzing or ringing sound in the ears—and others don't has puzzled scientists for years. Researchers funded by an NIDCD challenge grant from the American Recovery and Reinvestment Act (ARRA) are suggesting that vulnerability to tinnitus resides in the limbic system—a linked network of brain structures involved in emotion, behavior, and long-term memory. Josef Rauschecker, Ph.D., D.Sc., and his team of researchers at Georgetown University propose that these limbic structures act as a gatekeeper to keep the tinnitus signal from reaching the part of the brain that mediates our conscious perception of sound. People whose limbic systems are less successful at suppressing the signal develop tinnitus. Rauschecker and his team base their theory upon imaging studies that show brain volume loss in limbic areas that interact with the auditory system and hyperactivity in other areas that appears to be trying to make up for the loss. Their findings give other researchers a new set of places to explore where tinnitus could potentially be stopped.

Read more on the NIDCD website at **http://www.nidcd.nih.gov/news/releases/11/031611.htm**.

Earlier findings, which the ARRA-funded study built upon, have been published in *Neuron* at **http://www.ncbi.nlm.nih.gov/pubmed/21220097**.

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NIDCD-Supported Scientists Present Findings at ARO

New findings in auditory neuropathy, hyperacusis, and autoimmune-related hearing loss were presented at the Midwinter Meeting of the Association for Research in Otolaryngology (ARO) held in Baltimore in February.

Charles Liberman, Ph.D., presented findings from a collaborative study between his team at the Massachusetts Eye and Ear Infirmary and scientists in Brazil suggesting why some preterm infants develop hearing loss. Their study showed that the sensory cells that help amplify sound vibrations, called outer hair cells, are healthy, but the sensory cells that convert those vibrations to electrical signals that travel to the brain, the inner hair cells, have been destroyed. This causes a condition known as auditory neuropathy and explains why other researchers have observed a higher incidence of auditory neuropathy in preterm babies.

Craig Formby, Ph.D., at the University of Alabama, along with scientists from the University of Maryland and elsewhere, showed how a therapy for tinnitus (ringing in the ears) can help people with a sensitivity to sound, called hyperacusis, tolerate louder sounds. Participants in the study with hyperacusis who wore a noise-generating device in each ear that played a soft whooshing noise, and who also received counseling, were able to tolerate louder sound levels. Their next step is to evaluate a noise-generating device in combination with a hearing aid to see if they can enhance performance for hearing aid wearers by improving their tolerance to amplified sound.

Dennis Trune, Ph.D., and his team at Oregon Health & Science University presented findings that explained how glucocorticoids—a commonly prescribed family of drugs to treat hearing loss related to autoimmune diseases such as lupus and rheumatoid arthritis—don't work on inflammation as previously thought, but appear to correct an imbalance in ions in the fluid of the inner ear. Dr. Trune and his team propose that developing a treatment based on regulating ion concentration, instead of controlling inflammation, may be more effective and offer fewer side effects than steroids for people with autoimmune-related hearing loss.

Learn more about ARO at **http://www.aro.org**.

Smell and Taste Researchers Present Findings at AChemS Annual Meeting

NIDCD-supported researchers presented the results of their most recent work at the annual Association for Chemoreception Scientists (AChemS) meeting in St. Pete Beach, Fla., in April.

Hong Wang, Ph.D., and colleagues at the Monell Chemical Senses Center in Philadelphia used a mouse strain that models lupus in humans to explore how the effects of chronic inflammation on taste tissues can contribute to the loss of taste. They noted increased levels of inflammation-promoting immune system cells in the tongue tissue in association with lower numbers of the kind of taste cells that respond to sweet, bitter, and umami, or savory, flavors. Taste buds also appeared smaller. The research provides new evidence linking autoimmune disease and chronic inflammation to selective changes in the structure and function of taste tissues in the tongue.

Daniel Wesson, Ph.D., discussed work conducted with colleagues at the Nathan S. Kline Institute for Psychiatric Research, the NYU School of Medicine, and Case Western Reserve School of Medicine that proposes a pathological mechanism in the olfactory bulb that could play a key role in the progression of Alzheimer's disease. Using a mouse model that overexpresses a human mutation of a protein involved in making the plaques that form in the brains of Alzheimer's patients, Wesson and

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colleagues observed activity in the olfactory bulb that appeared to accelerate spread of plaques throughout the brain. Their findings offer three potential applications: a new diagnostic marker that could help doctors diagnose Alzheimer's at earlier stages of the disease; a potential treatment to restore olfactory function in Alzheimer's patients; and a novel pathway for exploring drugs that could, ideally, slow or stop the progression of Alzheimer's disease.

Learn more about AChemS at **http://www.achems.org**.

NIDCD Highlights

NIDCD Welcomes Dr. Lisa L. Cunningham

Lisa L. Cunningham, Ph.D., has joined the NIDCD Intramural Division as chief of the Section on Sensory Cell Biology. Her current research interests build on prior work studying the role of heat shock proteins (HSPs) in protecting hair cells against ototoxic drug–induced hearing loss and hair cell death. At the NIDCD she is leading a team aimed at understanding the molecular mechanisms underlying the protective effects of HSPs, and translating the findings into clinical therapies to prevent hearing loss caused by exposure to ototoxic drugs. Dr. Cunningham received a B.A. and M.A. in audiology from the University of Tennessee, Knoxville. She completed a clinical fellowship in audiology at Indiana University Medical Center in Indianapolis, and received a Ph.D. in neuroscience from the University of Virginia. She completed a post-doctoral fellowship in auditory neuroscience at the University of Washington in Seattle and was most recently at the Medical University of South Carolina.

Learn more about Dr. Cunningham's lab at **http://www.nidcd.nih.gov/research/scientists/LisaCunningham.htm**.

NIDCD Strategic Plan

Three working groups—one on hearing and balance, one on smell and taste, and one on voice, speech, and language—were held in March to help shape the 2012-2016 NIDCD Strategic Plan. Initial recommendations will be presented at the May 20 Advisory Council meeting. A full draft for public comment will be available after the September 16 Advisory Council meeting. You can see previous NIDCD Strategic Plans at **http://www.nidcd.nih.gov/about/plans/strategic/**.

Noisy Planet Has a New Partner!

The Acoustical Society of America (ASA), a professional organization that promotes the understanding and practical applications of acoustics, is Noisy Planet's newest partner. Noisy Planet partners help extend the reach of the Noisy Planet campaign to parents and other adults who influence the health behavior of tweens (children ages 8 to 12). ASA has disseminated Noisy Planet materials in English and Spanish to its members at national conferences and to several Girl Scout troops. They continue to explore ways to collaborate. To learn about other partners, visit the Noisy Planet Community and Partners Web page at **http://www.noisyplanet.nidcd.nih.gov/partner/Pages/Default.aspx**.

Read more about ASA at **http://acousticalsociety.org/**.

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Grants News

NIDCD AREA Grants Give Undergrads the Chance to Conduct High Level Research

Christopher Platt, Ph.D., is a program director in the NIDCD's Division of Scientific Programs who administers the Academic Research Enhancement Awards, or AREA grants. AREA grants, which are also referred to as R15's, fund small-scale research projects in the biomedical sciences for undergraduate students across the country. Dr. Platt recently sat with the editor of INSIDE to answer some questions about this program and its importance in the NIDCD grant portfolio.

INSIDE: How long has the NIH been awarding AREA grants?

CP: The program began in 1985.

INSIDE: How many grants does the NIDCD award every year?

CP: We set aside funds for two awards per year. Across NIH, about 200 awards are made every year.

INSIDE: What kinds of schools apply for AREA grants?

CP: It's evolved over the years to include not just small liberal arts colleges, but smaller campuses in state university systems as well as health-related professional schools affiliated with major medical schools. About two-thirds of the grantees are at public colleges or universities.

INSIDE: How many students who participate in the program go on to graduate school or end up as biomedical researchers?

CP: Judging from what we read in many of the final reports we receive from the principal investigators on the grants, many of their students go on to graduate school, but we don't know the actual numbers. Sometimes we'll hear from current biomedical researchers that an early experience on an R15 was an important factor in their career choice.

INSIDE: Tell me about FUN!

CP: The Faculty for Undergraduate Neuroscience (FUN) is an organization of small colleges—many of them recipients of AREA awards—that hosts a get-together at the Society for Neuroscience's (SFN's) annual meeting. It's the most widely attended social at SFN, with a poster session and awards for outstanding teachers and students. Their enthusiasm about participating in important research is obvious. Most of these faculty members have positions that predominantly involve teaching, so for them, the ability to do lab research, and involve students, is a special opportunity that goes beyond their regular job.

INSIDE: Why are these grants important? What do they provide that other grant mechanisms can't?

CP: An R15 grant gives good scientists who aren't in research-intensive institutions the opportunity to do peer-reviewed biomedical research and it gives undergrads hands-on experimental experience that's not possible with an R01 grant, which emphasizes graduate or post-doc experience.

Learn how to apply for an AREA grant at **http://grants.nih.gov/grants/guide/pa-files/PA-10-070.html.**

Meetings of Interest

Hearing Loss Association of America, HLAA
June 16-19, Washington, DC
Web info: **http://www.hearingloss.org**

The Hearing Loss Association of America's (HLAA's) Convention 2011 brings together people with hearing loss and professionals. Highlights include a research symposium on the impact of noise on hearing, and the 2nd International Hearing Loop Conference focusing on hearing loop technology. The educational workshop topics include: advocacy and government affairs, hearing technology, medical issues, relationships (with friends, family, and employer), and young adults.

National Association of School Nurses, NASN
June 29-July 3, Washington, DC
Web info: **http://www.nasn.org/**

The National Association of School Nurses' 43rd Annual Conference, NASN 2011, provides excellent opportunities to learn, share ideas, and raise the profile of school nurses in the national child health policy under the banner *Vision, Voice, Visibility: Setting Sail Toward Healthy Horizons*.

Beyond the NIDCD: News from Other Organizations

The **National Consortium on Deaf-Blindness (NCDB**) is offering new publications in their Practice Perspectives series. *Authentic Assessment* describes a comprehensive approach to assessment that emphasizes gathering information about children in their everyday environments during normal activities. *College Students Who Are Deaf-Blind* is a summary of a research study on the experiences of 11 college students who are deaf-blind. It also provides suggestions for ways that colleges can support students with deaf-blindness. For these and other NCDB publications, go to their website at **http://nationaldb.org/NCDBProducts.php?prodID=111**. Each is available in standard print, large print, and Spanish. For bulk orders or braille copies, contact NCDB by phone at (800) 438-9376 or (800) 854-7013 (TTY) or by e-mail at **info@nationaldb.org**.

Dangerous Decibels is offering its next Educator Training Workshop on August 4-5, 2011, in Portland, Ore. This two-day certification workshop (16 hours) is open to people of all professional and educational backgrounds and is led by Oregon Health & Science University, Portland State University, and University of Northern Colorado hearing conservation, health communication, and educational outreach experts. The workshop prepares and equips participants to expertly present a K-12 classroom program that is proven effective at changing knowledge, attitudes, and intended behaviors in students regarding their hearing health. Instruction includes classroom management, hands-on activities, and an opportunity to deliver the program to instructors for critique and feedback. Instructors are available after the workshop for continued e-mail or phone support. Participants receive an educator kit with graphics, simulations, supplies, a script, and a sound level meter needed to present the classroom program. For more details go to their website at **http://www.dangerousdecibels.org** or e-mail **howarthl@ohsu.edu**.

The **American Tinnitus Association (ATA)** is sponsoring the "Jack Vernon Walk to Silence Tinnitus" on Saturday, June 25, 2011 at Willamette Park in downtown Portland, Ore. The walk is a fundraiser to support the ATA's research grant program and also includes an online walk. The physical walk begins at 10:00 a.m. and lasts until approximately 12:00 p.m. and there are prizes for the highest fundraising teams and a raffle for all physical participants. The online walk is happening now and continues through the end of June. To join the online walk, go to their website at **http://walk.ata.org**.

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New Resources

Updated Fact Sheets on Infant Hearing Screening and Speech and Language Development Now Available

Updated fact sheets on issues related to infant screening for hearing loss, a checklist for parents to keep track of their baby's hearing and development of communication skills, and the milestones of speech and language development are now available in print and online at the NIDCD website.

It's Important to Have Your Baby's Hearing Screened

Most babies have their hearing screened before they leave the hospital to identify a possible hearing loss. This fact sheet informs parents about what to expect during their baby's hearing screening and offers ideas and resources for parents. Read and print the fact sheet at **http://www.nidcd.nih.gov/health/hearing/screened.html**.

What to Do if Your Baby's Screening Reveals a Possible Hearing Problem

This fact sheet describes in detail what parents should do if their child does not pass the hearing screening, including when to schedule the follow-up examination as well as communication options that are available if your child has hearing loss. Read and print the fact sheet at **http://www.nidcd.nih.gov/health/hearing/baby_screening.html**.

Your Baby's Hearing and Communicative Development Checklist

Hearing problems in children can delay the development of voice, speech, and language skills. This checklist represents the average age by which most children accomplish a variety of early speech and language skills. Read and print the fact sheet at **http://www.nidcd.nih.gov/health/hearing/silence.html**.

Speech and Language Developmental Milestones

Children vary in their development of speech and language skills. This checklist of milestones for the normal development of speech and language skills in children from birth to 5 years of age helps doctors and other health professionals determine if a child is on track or if he or she may need extra help. Read and print the fact sheet at **http://www.nidcd.nih.gov/health/voice/speechandlanguage.html**.

Check the NIDCD website at **http://www.nidcd.nih.gov** for more information on hearing and voice, speech, and language disorders or call the NIDCD Clearinghouse at (800) 241-1044 or (800) 241-1055 (TTY).

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